COMPOSITE ARTICLE HAVING THERMOPLASTIC ELASTOMER REGION ON THERMOPLASTIC SUBSTRATE

Cross References To Related Applications

[0001] This application claims priority from United States Provisional Patent Application No. 60/414,312, filed September 27, 2002.

Statement Regarding Federally Sponsored Research

[0002] Not Applicable.

Background Of The Invention

[0003] It is often desirable to manufacture a single component which has the hardness and frictional properties of a thermoplastic elastomeric material in one region and the hardness and frictional properties of another thermoplastic material in other regions. For example, the thermoplastic elastomeric material may provide functions such as a built in gasket, or soft grip for "non-slip" handling, or skid free standing plane, or a high friction top to a modular belt or conveyor chain. The harder thermoplastic material can provide structure or mechanical strength to the component. In one example application, a thermoplastic elastomer, such a styrenic block copolymer, is laminated to a hard resin. The laminate is advantageous since it has a good feel, shock absorption (cushionability) and damage-resistance because of the flexibility and elasticity of the layer of the thermoplastic elastomer and has shape-retaining and reinforcing ability because of the hard resin.

[0004] While composites of a thermoplastic elastomer and a hard resin often have advantageous properties, it may be difficult to create an acceptable bond between the thermoplastic elastomer and the hard resin. Often mechanical coupling methods must be employed in which the thermoplastic elastomer and the hard resin are formed to have engaging means capable of being coupled together. However, the formation of engaging means typically require molds with complicated structures for forming the engaging means. Alternatively, the thermoplastic elastomer and the hard resin are often bonded together with some other bonding means, such as adhesives. The use of adhesives is also undesirable because it requires complicated steps to prepare the two layers followed by bonding. As a result, poorly-bonded composites are often produced, and organic solvents in adhesives often are detrimental in the working environment.

[0005] What is needed therefore is a method and materials wherein a thermoplastic elastomeric material can be readily molded to another harder thermoplastic material such that an acceptable bond forms between the thermoplastic elastomer and the harder thermoplastic material.

Summary Of The Invention

[0006] The present invention provides a formulation to attach a thermoplastic material comprising a thermoplastic urethane to a thermoplastic alloy of a polyester and a polycarbonate. In one form, the thermoplastic material includes a styrenic thermoplastic elastomer and the thermoplastic urethane. Molded components can be manufactured using an alloy blend of a polyester and a polycarbonate. Components can then be manufactured which include a significant bond between the thermoplastic alloy of a polyester and a polycarbonate and the thermoplastic material. The materials can be attached by a process such as injection molding, extrusion, or another process known in the art for processing thermoplastics including multi-barrel injection molding and co-extrusion.

[0007] One advantage of the invention is to attach a relatively soft thermoplastic material, such as a thermoplastic elastomer, to a significantly harder thermoplastic material. This is advantageous in that a single component can be manufactured which has properties of the soft material in one region or part feature and the properties of the harder material in other regions or part features. The soft material may provide function such as a built in gasket, or soft grip for “non-slip” handling, or skid free standing plane, or a high friction top to a modular belt or conveyor chain, etc. The hard material can provide structure or mechanical strength to name a few features.

[0008] These and still other advantages of the present invention will be apparent from the description which follows. In the detailed description below, preferred embodiments of the invention will be described. These embodiments do not represent the full scope of the invention. Rather the invention may be employed in other embodiments. Reference should therefore be made to the claims herein for interpreting the breadth of the invention.

Description of the Drawings

[0009] Figure 1 is an exploded perspective view of a portion of a modular conveyor chain including a modular chain link formed using the present invention.

Detailed Description Of The Invention

[0010] The present invention provides a method for attaching a softer thermoplastic material to a harder thermoplastic material. In one embodiment, a thermoplastic material comprising a thermoplastic polyurethane can be attached to a thermoplastic alloy of a polyester and a polycarbonate. In another embodiment, a thermoplastic elastomer alloy including a styrenic thermoplastic elastomer and a thermoplastic polyurethane can be attached to a thermoplastic alloy of a polyester and a polycarbonate. The materials can be attached by a process such as injection molding, extrusion, or another process known in the art for processing thermoplastics including multi-barrel injection molding and co-extrusion. For example, one material can be injection molded (by insert molding or 2-shot), extruded (or co-extruded) or thermally processed in some manner which allows the second material to bond thermally or chemically.

[0011] In one form, the invention provides a molded article including a substrate comprising a thermoplastic alloy including a polyester and a polycarbonate, and a layer of a thermoplastic material disposed on at least a portion of the substrate. The thermoplastic material may comprise a thermoplastic polyurethane, or a thermoplastic elastomer alloy including a styrenic thermoplastic elastomer and the thermoplastic polyurethane. Optionally, the thermoplastic material may consist essentially of the thermoplastic polyurethane. Optionally, the thermoplastic elastomer alloy may consist essentially of the styrenic thermoplastic elastomer and the thermoplastic polyurethane.

[0012] The styrenic thermoplastic elastomer is preferably a styrenic block copolymer. Non-limiting examples of styrenic block copolymers include styrene-butadiene-styrene (SBS) copolymers, styrene-isoprene-styrene (SIS) copolymers, styrene-ethylene/butylene-styrene (SEBS) copolymers, and styrene-ethylene/propylene-styrene (SEPS) copolymers. In one example form of the invention, the styrenic block copolymer is selected from styrene-ethylene/butylene-styrene copolymers.

[0013] The polyurethane has no limitation in respect of its formulation other than the requirement that it be thermoplastic in nature. Such thermoplastic polyurethane compositions are generally referred to as TPU materials, and any TPU materials that are compatible with the styrenic thermoplastic elastomer can be used in the thermoplastic elastomer alloy of the present invention. For particular teachings on various TPU materials and their preparation, see U.S. Patent Nos. 2,929,800; 2,948,691; 3,493,634; 3,620,905; 3,642,964; 3,963,679; 4,131,604; 4,169,196; Re 31,671; 4,245,081; 4,371,684; 4,379,904; 4,447,590; 4,523,005; 4,621,113; and 4,631,329 whose disclosures are hereby incorporated herein by reference.

[0014] Thermoplastic elastomer alloys including a styrenic thermoplastic elastomer and a thermoplastic polyurethane are commercially available. One preferred thermoplastic elastomer alloy for use in the present invention is an SEBS/Urethane TPE/TPU alloy sold under the designation Versaflex™ OM 1245X-1 by GLS Corporation, McHenry, Illinois, USA. When attached to the thermoplastic alloy substrate, the thermoplastic elastomer alloy has a hardness in the range of 40-70 Shore A as measured using the procedures of ASTM D2240. The hardness selected for the thermoplastic elastomer alloy is typically lower than that of the thermoplastic alloy substrate.

[0015] The polyester used in the thermoplastic alloy comprising the substrate is typically the reaction product of a polyhydric alcohol and a polycarboxylic acid. For example, the polyester may be the reaction product of an alkanediol and terephthalic acid. Preferably, the polyester is selected from polyethylene terephthalate and polybutylene terephthalate, and most preferably, the polyester is polybutylene terephthalate.

[0016] The polycarbonate used in the thermoplastic alloy comprising the substrate is typically is a bisphenol-A polycarbonate. Most preferably, the polycarbonate is the reaction product of bisphenol-A and diphenyl carbonate.

[0017] Thermoplastic alloys including a polyester and a polycarbonate are commercially available. Several preferred thermoplastic alloys for use in the substrate of the present invention are sold under the designation Xenoy™ by General Electric Plastics, Pittsfield, Massachusetts, USA. One preferred thermoplastic alloy for use in the substrate of the present invention is sold under the designation Xenoy™ 1200 and comprises an alloy of polybutylene terephthalate (PBT) and a bisphenol-A polycarbonate (PC). Typically, the bisphenol-A polycarbonate is the reaction product of bisphenol-A and a carbonate diester such as diphenyl carbonate.

[0018] The thermoplastic material comprising a thermoplastic polyurethane, or the thermoplastic material comprising a thermoplastic elastomer alloy including a styrenic thermoplastic elastomer and the thermoplastic polyurethane may be attached to the thermoplastic alloy substrate using conventional methods. The materials can be attached by a process such as injection molding, extrusion, or another process known in the art for processing thermoplastics including multi-barrel injection molding and co-extrusion. Examples of co-extrusion methods and equipment can be found in U.S. Patent Nos. 4,405,547, 4,054,403 and 3,649,143 which are incorporated herein by reference. In an injection molding process, an article having thermoplastic elastomer alloy and the thermoplastic material laminated layers is constructed by first injection molding the hard thermoplastic alloy into a suitable mold, and then forming an outer surface portion by injecting the soft thermoplastic material onto a portion of the hard thermoplastic alloy. Another method comprises constructing each of the layers separately, and one surface of the soft thermoplastic material portion is then fastened by cementing (e.g., by an adhesive) to the complementing surface of the hard thermoplastic alloy. In the version of the invention using a thermoplastic material comprising a thermoplastic elastomer alloy including a styrenic thermoplastic elastomer and the thermoplastic polyurethane, there may be a significant advantage to having either the styrenic thermoplastic elastomer phase or the thermoplastic polyurethane phase of the thermoplastic elastomer alloy as large as possible in order to increase the bond strength with the substrate.

[0019] With respect to the substrate, polycarbonates may not be a very good material for making certain components. For instance, polycarbonates are not very good materials for making conveyor chain or modular belting. Polycarbonate is an amorphous material which does not have very good mechanical properties, especially fatigue resistance, which is required for a conveyor chain application. Polybutylene terephthalate; however, is highly crystalline and is well known to be a good chain material. Thus, there may be a significant advantage to having either the polyester phase or the polycarbonate phase in the thermoplastic alloy as large as possible. In the thermoplastic alloy of a polyester and a polycarbonate, it is recognized that increasing the amount of polycarbonate may significantly reduce the mechanical properties of the material. However, adjusting the block length of the polycarbonate in the thermoplastic alloy of the polyester and the polycarbonate may allow a larger region for the polycarbonate phase in the thermoplastic alloy to attach to the thermoplastic material. Likewise, larger polycarbonate regions or phases in the thermoplastic alloy of a polyester and a polycarbonate may allow for better places to attach to the thermoplastic urethane or the thermoplastic urethane of the thermoplastic elastomer alloy.

[0020] In one application, one or more of the modular chain links of a modular conveyor chain can be formed using the present invention. A portion of a modular conveyor chain is shown in Figure 1. A modular chain link 13 formed using the present invention is shown intermeshed with a conventional adjacent chain link 15. A connector pin 17 pivotally connects the chain link 13 with the adjacent chain link 15.

[0021] The chain link 13 includes a link body 16 and a layer 99 disposed on the top of the link body 16. The link body 16 is formed from any of the thermoplastic alloy substrate materials described above such as the materials including a polyester and a polycarbonate. A preferred thermoplastic alloy for use in the link body 16 is sold under the designation Xenoy™ 1200 and comprises an alloy of polybutylene terephthalate (PBT) and a bisphenol-A polycarbonate (PC). Typically, the bisphenol-A polycarbonate is the reaction product of bisphenol-A and a carbonate diester such as diphenyl carbonate. The top layer 99 is formed from any of the thermoplastic materials described above such as the materials including a thermoplastic polyurethane or a styrenic thermoplastic elastomer and a thermoplastic polyurethane. One preferred thermoplastic material for use in the top layer 99 is an SEBS/Urethane TPE/TPU alloy sold under the designation Versaflex™ OM 1245X-1 by GLS Corporation, McHenry, Illinois, USA. The link body 16 and the top layer 99 may be attached using the conventional methods (i.e., injection molding, extrusion, cementing) described above. When attached to the link body 16, the top layer 99 has a hardness in the range of 40-70 Shore A as measured using the procedures of ASTM D2240. The hardness selected for the top layer 99 is typically lower than that of the link body 16.

[0022] The link body 16 includes a series of link ends 25 extending from opposite sides of the link body 16. The link ends 25 are transversely spaced from each other to define therebetween a series of spaces 27. The series of link ends 25 include openings 33 that are axially aligned with respect to each other. The openings 33 in the link ends 25 can be cylindrical or elongated in the direction of travel of the modular conveyor belt.

[0023] The adjacent chain link 15 is preferably the same general shape as the chain link 13. The adjacent chain link 15 also includes a series of link ends 65 that are axially spaced from each other to define a series of spaces 67. The series of spaces 67 are adapted to receive the series of link ends 25 located on one side of the chain link 13. The link ends 65 extend into the spaces 27 between the link ends 25 of the chain link 13. The link ends 65 in the adjacent link 15 also include openings 69 that are axially aligned with respect to each other as well as the openings 33 in chain link 13 when the adjacent link 15 is assembled to the chain link 13. The openings 69 may be cylindrical or elongated in the travel direction of the modular conveyor chain.

Example

[0024] Experiments were conducted with bonding a thermoplastic elastomer alloy (SEBS/Urethane TPE/TPU) sold under the designation Versaflex™ OM 1245X-1 by GLS Corporation, McHenry, Illinois, USA and a thermoplastic alloy sold under the designation Xenoy™ 1200, which comprises an alloy of polybutylene terephthalate (PBT) and a bisphenol-A polycarbonate (PC). The results were very positive in that they showed good adhesion between these two materials. Thus, it is possible to chemically bond a SEBS/Urethane based TPE/TPU alloy to a polycarbonate/PBT substrate. It is known that PC/PBT alloys have some unique properties which have a wide variety of applications. Alloying PC and PBT bring chemical resistance, thermal stability, and mechanical properties from the crystalline PBT component along with the toughness of the PC component. Bonding a soft material to this alloy has market value not only for conveyor chains, but also for a wide variety of other products such as power tool housings, automotive components, household appliances, and the like.

[0025] Therefore, the present invention provides a method and materials wherein a softer thermoplastic material can be readily molded to another harder thermoplastic material such that an acceptable bond forms between the softer thermoplastic material and the harder thermoplastic material. In particular, the invention provides a method and materials wherein a layer of a thermoplastic material comprising a thermoplastic polyurethane or a thermoplastic elastomer alloy including a styrenic thermoplastic elastomer and a thermoplastic polyurethane can be attached to a substrate comprising a thermoplastic alloy including a polyester and a polycarbonate.

[0026] While there has been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention defined by the appended claims.